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ZEKTOR™

Home Theater Solutions

HDMI5

(Supplement to the HDMI5 User Guide)

Digital Video Switch

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HDMI5 Command Ref. *(Cont'd)*

HDMI5 Command Ref. *(Cont'd)*

Mode 1

Relays toggle when activated by button press, or RS-232 command. Selecting inputs has no affect on the relays, and any 'time' value given is ignored.

Mode 2

Relays stay on for a momentary amount of time when activated by a button press, or RS-232 command. The value 'time' indicates the amount of time the relay stays on (in 15.626ms increments). If time is set to '0', then relays will toggle like Mode 1. Selecting inputs has no affect on the relays.

Mode 3

Relays become active when either a video or audio input is selected and the bit for that input is set to '1' in the 'vid_msk' or 'aud_msk' parameter. The 'time' value given is how long a relay remains active after a input is selected that does not match a '1' bit in 'vid_msk' or 'aud_msk'.

Mode 4

Relays become active for a momentary amount of time when either a video or audio input is selected and the bit for that input is set to '1' in the 'vid_msk' or 'aud_msk' parameter. The 'time' value given is how long a relay remains active before turn off.

The following examples set Relay '1' to the four different modes:

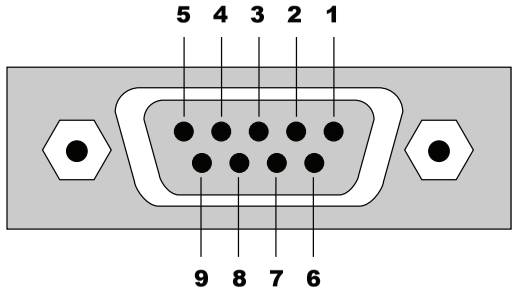
`RLS 1,0,,0,0`	Set to "Mode 0", 'timing' values are ignored
`RLS 1,1,`time`,0,0`	Set to "Mode 1", time not set to 0
`RLS 1,0,`time`,`vid_msk`,`aud_msk	Set to "Mode 3", at least one mask not set to 0
`RLS 1,1,`time`,`vid_msk`,`aud_msk	Set to "Mode 4", at least one mask not set to 0

The RS-232 Port

The RS-232 port on the HDMI5 is the same format, and pinout, as a PC-modem, and uses the same type of cable as a standard serial modem would, which is a standard straight through cable. Do not use a cable that is marked as a "Null Modem" cable.

The HDMI5 can also be used with any USB to RS-232 conversion cable, these are all typically straight through cables.

The RS-232 port is a female type DE-9 connector (sometimes mistakenly referred to as a DB-9 connector) with the following pinout:



Pin definitions:

`1 - No Connect`	`6 - No Connect`
`2 - TX`	`7 - No Connect`
`3 - RX`	`8 - No Connect`
`4 - No Connect`	`9 - No Connect`
`5 - GND`	

The port settings used by the HDMI5 are:

```
Baudrate:   9600
Data Bits:  8
Stop Bits:  1
Parity:     NONE
```

K.I.S.S.™ (Keep It Simple Serial™)

The K.I.S.S.™ Command Structure

The following conventions are used to describe the protocol:

<CR> = An ASCII Carriage Return ('0D' hex)
<LF> = Line Feed ('0A' hex)
<ESC> = An Escape character ('1B' hex)
CMD = A command, consisting of only alpha characters (A-Z, a-z).
ERR = An error code value, consisting of only decimal digits (0-9).

Device = The Zektor device being controlled.
Controller = A PC or other system, used to control the Zektor device.
Parameter = A decimal value that may, in some cases, be prefixed with '+' or '-' (+,-,0-9).

A K.I.S.S.™ command in its simplest form is a **CMD** following by a **<CR>** for instance:

```
V<CR>
```

This will return the version number of a Zektor device.

A command can have a variable number of parameters with optional whitespace(s) following the command, for instance:

```
P1<CR>
```

or

```
P 1<CR>
```

will turn on the power of most Zektor devices. The spaces between the 'P' and '1' are optional. Since commands consist of alpha characters only, there can never be a 'P1' command and 'P1' will always be interpreted as 'P 1'.

When a command has more than one parameter, the parameters are separated by either whitespace(s) or a comma, or both whitespace(s) and a comma, for instance:

```
LI 3 13<CR>
```

or

```
LI 3 , 13<CR>
```

will set the lower and upper LED front panel intensity levels of most Zektor devices. Once again the space between the command and 1st parameter is optional. Space(s) may also appear before and after the comma.

The comma is optional between parameters except when it is necessary to indicate a default parameter, for instance:

```
LI ,13<CR>
```

would set the upper intensity level of the front panel LEDs without affecting the lower level. The comma is used to indicate the 1st parameter is not supplied and the default value should be used (in this case the value defaults to the current setting, leaving the value unchanged). The

HDMI5 Command Ref. *(Cont'd)*

Where:
rly_n = Relay number (1 or 2).
state = State of relay (0=Off, 1=On, 2=Toggle).
$ = If present, settings are backed up in EEPROM.

Relay Settings

Setup the behavior of the relays.

RLS rly_n,mom,time,vid_msk,aud_msk,**$**	New settings
RLS rly_n,**?**	Query 'rly_n' settings
RLS ?	Query both relay settings

Response String:

=RL rly_n,mom,time,vid_mask,aud_mask

Where:
rly_n = Relay number (1 or 2).
mom = Momentary mode (0=Static, 1=Momentary).
time = Relay delay time in 15.626 millisecond increments.
vid_msk = A bitmapped value of video channels affecting relay.
aud_msk = A bitmapped value of audio channels affecting relay.
$ = If present, settings are backed up in EEPROM.

'vid_msk' and 'aud_msk' are a bitmapped parameters, mapped as follows:

Decimal Value	+128	+64	+32	+16	+8	+4	+2	+1
Bit Position	7	6	5	4	3	2	1	0
Name	0	0	0	IN5	IN4	IN3	IN2	IN1
Factory Settings:	0	0	0	0	0	0	0	0

IN1-IN5 - 0 input does not affect relay. 1=Input triggers relay when input is selected.
0 - Reserved, always set to 0.

This command allows setting up all relay modes of operation. The four relay modes specified in the user manual are based on an interaction of the parameters supplied.

The four modes are:

Mode 1 = Toggle Mode.
Mode 2 = Momentary Mode.
Mode 3 = Channel Select.
Mode 4 = Channel Select Momentary Mode.

'clt' is a bitmapped parameter, mapped as follows:

Decimal Value	+128	+64	+32	+16	+8	+4	+2	+1
Bit Position	7	6	5	4	3	2	1	0
Name	0	0	0	0	0	DJT	HEN	VEN
Factory Settings:	0	0	0	0	0	0	0	0

VEN - 0=Vertical sync pass through. 1=Vertical sync always low.
HEN - 0=Horizontal sync pass through. 1=Horizontal sync always low.
DJT - 0=Horizontal dejitter off. 1=Horizontal dejitter on.
0 - Reserved, always set to 0.

Switching Delays

Allows setting of the Video and Audio switching delays.

SD video_delay,audio_delay,**$**	Set new settings
SD ?	Query for current settings
SD	Query for current settings

Response String:

=SD video_delay,audio_delay

Where:
video_delay = Video switching delay in 15.626 millisecond increments.
audio_delay = Audio switching delay in 15.626 millisecond increments.
$ = If present, settings are backed up in EEPROM.

Relay Control

Controls the state of the relays.

RL rly_n,state,**$**	Set the state of relay 'rln'
RL rly_n,**?**	Read the state of relay 'rln'
RL ?	Read the state of both relays

Response String:

=RL rly_n,state

space before the comma is optional.

Most commands can be queried for their current settings by substituting the '?' for the parameter list, or by not supplying any parameters at all. For instance to request the current LED Intensity settings:

LI ?<CR>

or

LI<CR>

This would cause the device to issue a LED Intensity Response, (the Response String format is described in the section entitled: *"The Response String"*). The whitespace before the '?' is optional.

Most Zektor products use the K.I.S.S. command structure, the examples given here to describe syntax, may differ slightly from the commands used by your device. Please see the "Command Reference" section for the specific commands used by your device.

Using Bitmapped Parameters

Some commands accept "Bitmapped" parameters. These are decimal values that represent a series of flags, or bits, that control, enable and/or disable different device operations.

Binary arithmetic is used to represent bitmapped parameters, it is assumed the reader has some familiarity with binary arithmetic.

An example of a command that uses a bitmapped parameter is the **CVS4's** "**XS** settings**<CR>**" command, which is defined like this:

XS settings**<CR>**

Where 'settings' is a bitmapped parameter:

Decimal Value	+128	+64	+32	+16	+8	+4	+2	+1
Bit Position	7	6	5	4	3	2	1	0
Name	0	CRC	CSE	IRJ	IRS	IRE	FP	AS
Factory Settings:	0	0	0	1	1	1	1	0

AS - 0=Master / Slave mode. 1=Asynchronous Mode.
KB - 0=Disable Front Panel. 1=Front Panel Enabled
IRE - 0=Disable IR. 1=Enable IR.
IRS - 0=Turn off IR Sensor. 1=Turn on IR Sensor.
IRJ - 0=Turn off IR Jack. 1=Turn on IR Jack.
CSE - 0=Disable CS and CRC-8 1=Append either Checksums or CRC-8 to responses.
CRC - 0=Append Checksums or, 1=Append CRC-8's to reponses.
0 - Reserved, always set to 0.

This indicates the parameter 'settings' is bitmapped parameter, followed by a description of what each bit represents.

The 'Decimal Value' in the table's header, refers to the values added together to create the deci-

mal parameter used by the command. For instances if the bits 'AS' and 'IJ' where to be set to 1, and the rest of the bits set to zero, the parameter value would be calculated as: 8+1, making the parameter value: 9.

The command to directly set those two bits, and reset all the others would be:

XS 9<CR>

Individual bits of a bitmapped parameter can be set or reset without affecting the other bits, by prefixing the bitmapped parameter with a '+' to set individual bits, or a '-' to reset individual bits.

For instance in the above example the bitmapped value has been set to '9'. If we would now like to enable the IR remote, by setting the 'IRE' bit, the following command can be issued:

XS +4<CR>

The will set the 'IR' bit, and have no affect on the others, and the new "XS" value would be: 13

If we'd like to now disable the IR jack and the IR remote functions and the Front Panel, by clearing the 'IRJ', 'IRE' & 'FP' bits, we'd use the value "16+4+2", or 22, and issue the command:

XS -22<CR>

leaving the new "XS" value to be: 1.

Command Checksums and CRC-8 Checkcodes

A checksum or CRC-8 checkcode may be appended to any command, and if given, will be calculated by the device and compared with the given value. If a mismatch occurs an error will be returned and the command will not be executed. This can be used to help assure reliable operation in noisy environments. Checksums are more commonly used in serial protocols, however CRC-8 checkcodes offer a more secure means of insuring error free communications.

A checksum or CRC-8 checkcode is appended to the command by adding a semicolon (';') or colon (':') suffix character followed by the checksum or checkcode.

An example of appending a checksum to a command:

LI 2,13;178<CR>

the ';' indicates a checksum follows, the '178' is the checksum of the command string up to and including the ';' character.

In a similar fashion a CRC-8 checkcode can be appended to a command:

LI 2,13:213<CR>

The ':' indicates that a CRC-8 checkcode follows, the '213' is the calculated CRC-8 checkcode.

Optional spaces are allowed before the ';' and ':' characters but *NOT* after them. The checksum must *immediately* follow the ';' character, and a CRC-8 checkcode must *immediately* follow the ':' character, anything else, including whitespace, will cause a syntax error to be returned. Similarly the <CR> must *immediately* follow the checksum or checkcode parameter or a syntax error will

Response String:

=XE settings

Where 'settings' is a bitmapped parameter:

Decimal Value	+4096	+2048	+1024	+512	+256	+128	+64	+32	+16	+8	+4	+2	+1
Bit Position	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RS2	RS1	RL2	RL1	EQU	SWD	CTL	LMI	IRC	IRR	BTN	SEL	PWR
Factory Settings:	0	0	0	0	0	0	0	0	0	0	0	1	1

PWR - 1=Power State has changed.
SEL - 1=Selection (Input / Output Mapping) has changed.
BTN - 1=One or more buttons have been pressed.
IRR - 1=A new IR code has been received.
IRC - 1=New IR codes have been learned.
LMI - 1=Lighting Mode or Intensity Level Settings have changed.
CTL - 1=Control Settings have changed.
SWD - 1=Switching delays have changed.
EQU - 1=Equalization or Bandwidth settings have changed.
RL1 - 1=Auxiliary 1's relay has changed states.
RL2 - 1=Auxiliary 2's relay has changed states.
RS1 - 1=Auxiliary 1 relay's parameters have changed.
RS2 - 1=Auxiliary 2 relay's parameters have changed.

The '$' parameter is a "Backup Control Settings" flag. If it exists, then the current settings will be backed up in EEPROM, and will remain unchanged through a power failure. Backing up the "**Extended Control Settings**" will also backup the "**Control Settings**".

Input Equalization & Bandwidth

This command allows setting the equalization, bandwidth and control settings of the currently selected input.

EQU equ,bw,ctl,**$**

Where:
- equ = Indicates the cable length equalization setting (0=Shortest, 15=Longest).
- bw = Bandwidth setting. (0=4MHz, 1=3MHz, 2=6Mhz, 3=5MHz).
- ctl = Bitmapped control settings (See following bitmap table).
- **$** = If present, settings are backed up in EEPROM.

Response string:

=EQU equ,bw,ctl

HDMI5 Command Ref. *(Cont'd)*

Extended Control Settings

In the Asynchronous mode of operation, the HDMI5 will transmit state changes as they occur. This command allows individual control over which state changes will be sent.

This HDMI5 allows control over the following states:

- Power State changes (On / Off condition).
- Selection changes (input / output mapping changes).
- Front Panel modes and intensity changes
- Front Panel Button Presses.
- IR codes received.
- New IR codes learned.
- Control Settings changes.

Each of the above states can be selectively set to asynchronously transmit their state changes, or run in the Master / Slave mode. If asynchronous transmit has been disabled for one of the options, then that option will revert to the Master / Slave mode.

The 'AS' in the **"Control Settings"** command must be set to '1' to allow any Asynchronous transmissions, if the 'AS' bit is set to zero, then the HDMI5 will operate solely in the Master / Slave mode regardless of the settings of this command.

XE settings	Set the enable bits to 'settings'.
XE +settings	Set enable bits indicated in 'settings' to 1.
XE −settings	Reset enable bits indicated in 'settings' to 0.
XE settings**,$**	Set the control bits to 'settings', save in EEPROM.
XE +settings**,$**	Set bits indicated in 'settings' to 1, save in EEPROM.
XE −settings**,$**	Reset bits indicated in 'settings' to 0, save in EEPROM.
XE $	Back up current settings into EEPROM.
XE ?	Query for current settings.
XE	Query for current settings.

K.I.S.S.™ *(Continued)*

be returned.

See: **"Checksums and CRC-8's"** for more information on both, and source code examples of calculating both Checksums and CRC-8's as used by K.I.S.S.™.

Clearing the Command Buffer

All commands are buffered and nothing is executed until the **<CR>** character is received. To assure that there are no extraneous characters in the command buffer, before a command string is sent, the **<ESC>** character can be issued to clear the buffer and reset any checksum or CRC-8 checkcode calculations.

This is useful when communications with the Zektor device is being initialized and the state of the device is unknown. An **<ESC>** will clear the command buffer and reset all checksums and CRC-8 checkcodes.

For example:

dsLG%df<ESC>V;145<CR>

will return the Version Query Response string for most Zektor devices. The "**dsLG%df**" represents noise that could have been in the buffer before the command string was issued. The **<ESC>** clears the buffer allowing the "**V;145<CR>**" to be processed error free.

It is legitimate to prefix all commands with the **<ESC>** character to assure the buffer is always empty before the command string is received, which may be helpful in a very noisy environment.

The Response Strings

A response will always be returned whenever a **<CR>** is received. There are no conditions where a "timeout" is a valid response to any query.

There are only three valid responses in the K.I.S.S.™ protocol, anything else should be considered a communication error, including a timeout while waiting for a response.

Each response is prefixed by a unique character. Determining which of the three responses is received can be done simply, by examining only the first character of any response string.

The three possible prefix characters and their associated responses are

+	The Acknowledgement Response
!	The Error Response
=	The Query Response

The response to a command string will always be an Acknowledgement or an Error Response.

The Acknowledgement is always the string:

+<CR><LF>

K.I.S.S.™ *(Continued)*

and the Error Response is always the string:

!ERR<CR><LF>

By parsing only the prefix characters '+' and '!', a programmer can chose to ignore the error codes and simply look at the first characters of the response strings and use them as a pass / fail indicator when issuing a command.

All response strings always end with a **<CR><LF>**.

A Query Response string always starts with the '=' characters and is followed by a command string indicating the parameter being returned. This is better explained in an example.

Here's an example of a querying a device for its light intensity settings:

LI?<CR>	Sent: Light Intensity Query command
+<CR><LF>	Received: Acknowledgement of command
=LI 2,13<CR><LF>	Received: Light Intensity Query Response

Note that a "**+<CR><LF>**" followed the command string. A command string is *always* followed by either an Acknowledgment (as in this case) or an Error Response. This consistency allows a driver to use a single routine to issue a command and check for an Acknowledgement or an Error Response String, whether or not the command queries for a response.

An example of an error response:

IL?<CR>	Sent: Command characters transposed, no such command
!2<CR><LF>	Received: Error Response indicating unknown command

In this case the Error Response string "**!2<CR><LF>**" was issued instead of the acknowledgment string since the command was not recognized.

Response String Checksums and CRC-8 Checkcodes

Response strings can be programmed to have checksums or CRC-8 checkcodes appended to them, the syntax is identical to the Command Structure's checksum and CRC-8 handling.

Checksum and CRC-8 are turned on and off by issuing the proper command. On most devices this is the **"Control Settings"** command.

Only the Error Response and The Query Response strings will have checksum and CRC-8 checkcodes appended to them. The Acknowledgment Response will always consist of "+<CR><LF>". Anything else must be assumed to be a communication error.

An example with checksumming enabled, while querying for LED intensities is:

```
LI?<CR>
+<CR><LF>
=LI 2,13;239<CR><LF>
```


HDMI5 Command Ref. *(Cont'd)*

XS $	Back up current settings into EEPROM.
XS ?	Query for current settings.
XS	Query for current settings.

Response String:

=XS settings

Where 'settings' is a bitmapped parameter:

Decimal Value	+128	+64	+32	+16	+8	+4	+2	+1
Bit Position	7	6	5	4	3	2	1	0
Name	12V	CRC	CSE	IRJ	IRS	IRE	FP	AS
Factory Settings:	0	0	0	1	1	1	1	0

AS	- 0=Master / Slave mode.	1=Asynchronous Mode.
KB	- 0=Disable Front Panel.	1=Front Panel Enabled
IRE	- 0=Disable IR Control.	1=Enable IR Control.
IRS	- 0=Turn off IR Sensor.	1=Turn on IR Sensor.
IRJ	- 0=Turn off IR Jack.	1=Turn on IR Jack.
CSE	- 0=Disable CS and CRC-8	1=Append either Checksums or CRC-8 to responses.
CRC	- 0=Append Checksums,	1=Append CRC-8's, to responses.
12V	- 0=+12V disabled	1=Use IR Jack as +12V On / Off Control

The '$' parameter is a "Backup Control Settings" flag. If it exists, then the current settings will be backed up in EEPROM, and will remain unchanged through a power failure. Backing up the "**Control Settings**" will also backup the "**Extended Control Settings**".

The IR control (IRE) and the IR jack (IRS), work differently when disabled. Disabling IR control, by setting the 'IRE' bit to zero, keeps the HDMI5 from responding to any IR codes, however the front panel sensor remains operational and any codes received can still be queried for by using the "IR ?" command. Disabling the IR sensor (IRS) and enabling IR control (IRE), allows the HDMI5 to respond to IR signals through the IR jack, any signal received by the IR sensor will be ignored.

Disabling the IR jack, by setting the 'IRJ' bit to zero, completely disables the IR jack. IR commands are no longer be received through the IR jack if the 'IRJ' bit has been set to zero.

The 'IRJ' flag and '12V' are mutually exclusive. Any attempt to set them both will result in the '12V' being disabled.

Q ?	Query for current flag values.
Q	Query for current flag values.

Response String:

=Q flags

Where 'flags' is a bitmapped parameter:

Decimal Value	+4096	+2048	+1024	+512	+256	+128	+64	+32	+16	+8	+4	+2	+1
Bit Position	12	11	10	9	8	7	6	5	4	3	2	1	0
Name	RS2	RS1	RL2	RL1	EQU	SWD	CTL	LMI	IRC	IRR	BTN	SEL	PWR
Factory Settings:	0	0	0	0	0	0	0	0	0	0	0	1	1

PWR - 1=Power State has changed.
SEL - 1=Selection (Input / Output Mapping) has changed.
BTN - 1=One or more buttons have been pressed.
IRR - 1=A new IR code has been received.
IRC - 1=New IR codes have been learned.
LMI - 1=Lighting Mode or Intensity Level Settings have changed.
CTL - 1=Control Settings have changed.
SWD - 1=Switching delays have changed.
EQU - 1=Equalization or Bandwidth settings have changed.
RL1 - 1=Auxiliary 1's relay has changed states.
RL2 - 1=Auxiliary 2's relay has changed states.
RS1 - 1=Auxiliary 1 relay's parameters have changed.
RS2 - 1=Auxiliary 2 relay's parameters have changed.

Control Settings

Turn on and off operational modes of the HDMI5.

This command allows control over the following:

- Select the Master / Slave or Asynchronous modes of operations.
- Enable / Disable the front panel switches.
- Enable / Disable the IR control.
- Enable / Disable the IR jack.
- Enable / Disable appending Checksums or CRC-8's to responses.
- If enabled, choose whether Checksums or CRC-8's will be appended to responses.

XS settings	Set the control bits to 'settings'
XS +settings	Set bits indicated in 'settings' to 1.
XS –settings	Reset bits indicated in 'settings' to 0.
XS settings**,$**	Set the control bits to 'settings', save in EEPROM.
XS +settings**,$**	Set bits indicated in 'settings' to 1, save in EEPROM.
XS –settings**,$**	Reset bits indicated in 'settings' to 0, save in EEPROM.

An example with CRC-8 responses enabled is:

```
LI?:194<CR>
+<CR><LF>
=LI 2,13:87<CR><LF>
```

Notice that in the first example a checksum was not appended to the "**LI?**" command. When issuing a command the checksum and CRC-8 codes are sent on a command by command basis. Anytime a checksum or a CRC-8 code is appended to a command it will be checked and validated by the device, regardless of the "Response Checksum / CRC-8" settings.

When Response Checksums, or Response CRC-8 Checkcodes are enabled, Error Response strings will also have checksum and CRC-8 codes appended to them.

Master / Slave and Asynchronous Modes of Operation

The K.I.S.S.™ protocol can be used in a Master / Slave mode, where responses are only sent when requested, or in an Asynchronous mode, where responses are sent whenever the operational state of the device changes, such as a front panel button being pressed.

The Master / Slave Mode of Operation

In the Master / Slave mode, the controller requests information from the device at polled intervals. The control program assumes the role of the master, and the device is operated in the slave mode. No information will be sent from the device without first receiving a request from the controller.

For controllers that cannot handle having information being sent to them in the background, or at unspecified times, the Master / Slave setting is ideal, since all state changes will be logged but not sent until requested by the controller.

To allow for more efficient Master / Slave operations, there is a Query Status command available to the controller that return the status state of the device as a bitmap of flags indicating which states have changed and need querying. This allows the controller to poll, using a single command, and then based on those flag settings, issue only the commands needed to read the new state(s) of the device.

The Master / Slave mode also allows for a predictable communications flow. A communication sequence is always started by the controller by issuing a command. The response will always be either the Acknowledgement Response, or an Error Response, followed by (if a query command was issued) the Query Response. For instance:

LI ?<CR>	Sent: Controller issues a query command.
+<CR><LF>	Received: Acknowledgment (or possible Error) Response.
=LI 2,13<CR><LF>	Received: Query Response.

In the Master / Slave mode, the Acknowledgement or Error Response will always be the next re-

sponse string after a command is issued, and a Query Response will always follow an Acknowledgement Response.

The Asynchronous Mode of Operation

In the Asynchronous mode the device sends a Query Response string anytime there is a state change. For instance when an input is changed by the user by pressing a button on the front panel, or using a remote control, or by the IR jack, or even if a serial command has been issued, a Query Response string indicating an input change will be sent to the controller.

The advantage if this mode is the controller can be kept constantly in sync with the device without having to send periodic polling commands. This disadvantages are: The controller must be able to receive the Query Response strings in the background at unspecified times, and the communications flow is slightly more complicated.

When issuing commands in the Asynchronous mode, the controller must be aware of any unsolicited Query Responses that may be interjected into the communications flow.

For example:

LI?<CR>	Sent: Controller issues query command.
=O 1,3	Received: (unsolicited) Out 1 remapped to In 3.
+<CR><LF>	Received: Acknowledgment Response.
=P 0	Received: (unsolicited) Power turned off.
=LI 2,13<CR><LF>	Received: Query Response for LED intensities.

This represents a worst case scenario where unsolicited responses appear throughout the communication sequence.

First the "**LI?<CR>**" command was issued by the controller.

While looking for an Acknowledgement or Error Response string, an unsolicited Query Response is received, indicating the user has remapped Output 1 to Input 3, while the "**LI?<CR>**" command was being issued by the controller.

Next the Acknowledgment Response of the "**LI?<CR>**" command is received.

Next an unsolicited Query Response is received indicating the power has been turned off.

Finally the Query Response indicating the LED intensities is received.

The K.I.S.S.™ command structure was designed to make the above scenario very easy to deal with. Since all Query Responses start with the '=' character, it is easy to handle them asynchronously, as they are received. This is best done by writing a new "Get Response" routine that handles all Query Response internally (by looking for the '=' character), and only passing through non-query responses.

By using such a routine the above scenario becomes:

LI?<CR>	Sent: Controller issues command
+<CR><LF>	Received: Acknowledgement (or Error) Response

ated by the keyboard, making this command a bit more useful. These extended codes allow for better control of the HDMI5.

Some extended button codes are:

Code	Description
0	When Issued: Exits setup modes.
0	When returned by query: No buttons have been pressed since last the query.
100	Always toggle power (like Power Toggle without the need of a release code).
101	Discrete power on (always turns on power).
102	Discrete power off (always turns off power).
103	Sequence through inputs.
104	Discrete breakaway disable (always turn off breakaway).
105	Discrete audio breakaway.
106	Discrete video breakaway.
107	Turn on relay 1
108	Turn off relay 1
109	Turn on relay 2
110	Turn off relay 2

The '0' code has special meaning. When returned in a Query Response string it means there are no keys waiting in the buffer. When issue by the controller, it acts like an Exit key, used to exit setup modes, similar to pressing the Power Button, but it will be ignored if the HDMI5 is not in the setup mode. By issuing '0' codes, the HDMI5 can be returned to a known state, regardless of any possible setup state it might be in.

The '0' button code is also device independent. Its use, and value, does not change between Zektor devices like the other codes may (and most likely will).

Query Status

In the Master / Slave mode of operation, this command is used to poll for any pending state changes that are waiting to be read. By issuing this command and testing the returned bit-mapped value, the controller can determine what has changed in the HDMI5 since the last time it was polled.

This command allows the controller to quickly poll the HDMI5, using only one command, instead of issuing a string of commands to check if the power state has changed, or if a new input has been selected, a button pressed, etc.. The Query Status command is used to determine if *anything* has changed, and then based on the results of the Query Status, only the query commands needed are issued to read the new states of the HDMI5.

Once the new state is read by issuing the proper query command, the associated flag will be reset.

HDMI5 Command Ref. *(Cont'd)*

When used in combination with the "**Read Last IR Code**" command, even IR commands can be handled by the controller, outside the HDMI5's firmware.

Because of the tight link between this command and the HDMI5's firmware, there are some caveats when using this command. The Zektor firmware expects a button press code to always be followed by a button release code. Sending these codes out of logical order will not harm the HDMI5, but may result in unpredictable behavior (buttons codes ignored, or unexpected state changes).

B b1,bn...	Send one or more button codes to the HDMI5.
B ?	Query for any buffered button presses.
B	Query for any buffered button presses.

Response String:

=B b1,bn...

Where:

b1,bn.. = A variable number of button codes (1 to 16 codes per command).

In the Master / Slave mode, only the last 16 button presses will be logged between queries, after that, new button presses overwrite the old ones in the internal buffer and will be lost to the controller.

The maximum number of button codes that can be sent is 16. If more than 16 button codes are sent a "parameter count error" will be returned and only the first 16 button codes will be accepted.

The Button Codes for the HDMI5 are defined as follows:

Button	Press Code	Release Code
Power Toggle	10	19
Input 1 Select	2	20
Input 2 Select	3	21
Input 3 Select	4	22
Input 4 Select	5	23
Input 5 Select	6	24
'Sel' Button	7	25
'A1' Relay Toggle	8	26
'A2' Relay Toggle	9	27

The "Press Code" is the value returned when a button pressed, and the "Release Code" is the value returned when a button is released.

There are also a small number of codes that are unique to this command that cannot be gener-

K.I.S.S.™ *(Continued)*

The unsolicited Query Responses were handled internally by the new "Get Response" routine, and filtered from the communication flow, and only the Acknowledgement (or possible Error) Responses were allowed to pass. When the "**=LI 2,13<CR><LF>**" response is eventually received, it will be handled like any other unsolicited response.

Using K.I.S.S.™ in the Asynchronous mode is nearly as easy as using it in the Master / Slave mode, allowing for the creation of simple to write, but highly efficient device drivers.

Checksums and CRC-8's

Checksums and CRC-8 Checkcodes Defined

The use of a checksums or CRC-8 checkcodes can increase the reliability of communications between the controller and any Zektor device.

A checksum is calculated by using an unsigned byte as an accumulator, and adding together all the ASCII characters of a command string, up to and including the ';' character, while ignoring any overflow, and appending it as a decimal parameter to the end of the command.

A CRC-8 checkcode is calculated in a very similar way, but a CRC-8 algorithm is used instead of a simply adding together the ASCII characters. The CRC-8 byte is initialized to 'FF' hex, and the resultant value is sent inverted (one's compliment).

The CRC polynomial used is: x^8 +x^6 +x^3 +x^2 +1.

This polynomial was determined through exhaustive tests (all 8 bit polynomials tested), to be the best CRC-8 polynomial for arbitrarily length bit streams.

See paper entitled: "Cyclic Redundancy Code (CRC) Polynomial Selection For Embedded Networks" by Philip Koopman & Tridib Chakravarty. <http://www.ece.cmu.edu/~koopman/roses/dsn04/koopman04_crc_poly_embedded.pdf>

Another good source of CRC information is the CRC entry on Wikipedia, the free encyclopedia: <http://en.wikipedia.org/wiki/Cyclic_redundancy_check>

Differences between a Checksum and a CRC-8 Checkcode

A CRC is capable of finding many more and different types of errors than a checksum can. A good description of its capability is described in the above referenced articles, but a simple example show some of the differences well.

Here's an example of the intended command string:

```
LI 2,3
```

Here's some examples of the original and some badly formed strings, of the above example, and their associated checksums:

```
LI 2,3;129
LI 3,2;129
IL 2,3;129
KJ 2,3;129
```

Notice that every checksum is the same. Checksums cannot detected data being out of order. Checksums cannot detect errors where two bits, in the same position in two different bytes, are flipped. Checksums are not a very robust way to check for communication errors.

HDMI5 Command Ref. *(Cont'd)*

The value 'ircmd' refers to the IR commands that the HDMI5 is able to learn, they are:

IRCmd	Description
1	Power Toggle
2	Select Input 1
3	Select Input 2
4	Select Input 3
5	Select Input 4
6	Select Input 5
7	Audio / Video Breakaway Toggle
8	Auxiliary Relay 1 Toggle
9	Auxiliary Relay 2 Toggle
10	Discrete Power On
11	Discrete Power Off
12	Discrete Breakaway Off
13	Sequence through inputs
14	Discrete Audio Breakaway Select
15	Discrete Video Breakaway Select
16	Discrete Auxiliary Relay 1 On
17	Discrete Auxiliary Relay 1 Off
18	Discrete Auxiliary Relay 2 On
19	Discrete Auxiliary Relay 2 Off

Setting an 'ircmd' to 'ircode = 0', causes that command to no longer respond to IR.

IR codes are always saved in EEPROM.

Front Panel Button Emulation

This command allows access to the internal keyboard handling of the HDMI5, and is very hardware dependent. Button values returned by the HDMI5 may and most likely will be different than button values returned by other Zektor devices.

Each button generates a value upon being pressed, and a different value upon release.

The Power toggle button also generates a unique value when held for 4 seconds, which is used to enter the setup mode. Other combinations may also generate unique codes.

This command allows the controller to detect front panel button presses even when the front panel is disabled. This allows the controller very tight control over the HDMI5. By disabling the front panel (setting the FP bit to '0' in the "**Control Settings**" command), and by then processing the front panel button presses of the HDMI5, a controller can redefine the operations of the HDMI5.

keep the size of the IR response small, this command sends the 72 bit IR code as an 18 digit hexadecimal value.

IR ?	Query for the IR code of the last IR command received.
IR	Query for the IR code of the last IR command received.

Response String:

=IR ircode

Where:
ircode = 18 hex digits (0-9, A-F), representing the most recent IR code received.

This command returns a single digit '0' if there are no IR codes waiting to be read.

Set Learnable IR Command Codes

This command is used to set, or retrieve, the current IR codes associated with the learnable IR commands. This is useful for "cloning" the IR codes learned in one HDMI5 into another HDMI5.

IRC ircmd**,**ircode	Set the 'ircmd' to use the IR code 'ircode'.
IRC ircmd**,?**	Query for the 'ircode' for IR command 'ircmd'.
IRC ?	Query for all 'ircmd' settings.

Response String:

=IRC ircmd**,**ircode

Where:
ircmd = IR command number being set / retrieved (See Table).
ircode = 72 bit IR code (See: "IR" command).

For comparison, here are the same examples and their associated CRC-8 checkcodes:

```
LI 2,3:16
LI 3,2:114
IL 2,3:22
KJ 2,3:145
```

The CRC-8 checkcode easily catches these errors.

Source Code Example of Calculating a Checksum

The following is a simple "C" program that calculates the checksum of the string "TestString" and then prints the initial string with the calculated checksum appended to it.

```
#include "stdio.h"

int main( void)
{
    char           TestString[] = "LI 2,3";
    unsigned char  cksum;
    int            index;
    char           token = ';';

    cksum = 0; // initialize checksum

    // Checksum all of 'TestString[]'

    index = 0;

    while (TestString[index] != '\0')
        cksum += TestString[index++];

    // Add the checksum token character ';' to checksum

    cksum += token;

    // Print the results

    printf( "%s%c%u", TestString, token, (unsigned char)cksum);
    return (0);
}
```

Checksums and CRC-8's *(Cont'd)*

Source Code Example of Calculating a CRC-8 Checkcode

The following is a simple "C" program that calculates the CRC-8 of the string "TestString" and then prints the initial string with the calculated CRC-8 checkcode appended to it.

```
#include "stdio.h"

// Routine for updating the CRC-8 checkcode using a polynomial
// of: x^8 +x^6 +x^3 +x^2 + 1.
//
// To create the CRC8_POLY mask, we start by ignoring the highest
// bit (x^8) since it is assumed to always be 1 and lies outside
// our byte boundary, and doesn't affect our results.
//
// The rest of the bits of the polynomial are reversed from the
// polynomial's order. This allows us to read in each bit starting
// with bit 0 of each byte, instead of bit 7. This is done because
// the UART sends its LSB first and by doing the same we are able to
// preserve the CRC's burst error detection characteristics.
//
// So:
//    x^8 +x^6 +x^3 +x^2 + 1 = 101001101 = 14D hex
//    Ignore X^8:               01001101 =  4D hex
//    Reverse bit order:        10110010 =  B2 hex

#define  CRC8_POLY   0xB2            // polynomial mask
#define  CRC8_INIT   0xFF            // initial value

void crcByte( unsigned char *crc8, char cc)
{
    unsigned char  lcrc8;          // local copy of CRC-8 value
    int            bitcount;

    lcrc8 = *crc8;                 // get local copy of CRC-8

    // update CRC-8 with 8 new bits

    lcrc8 ^= cc;                   // test each bit against CRC-8

    for (bitcount = 0; bitcount < 8; bitcount++)
    {
        // if resultant bit was a 1, shift and xor in mask
        // else, just shift

        if (lcrc8 & 0x01)
            lcrc8 = ((lcrc8 >> 1) & 0x7F) ^ CRC8_POLY;

        else
            lcrc8 = (lcrc8 >> 1) & 0x7F;
    }
    *crc8 = lcrc8;                 // return new CRC8
}
```


HDMI5 Command Ref. *(Cont'd)*

Where 'mode' settings are:

0 = Turn off front panel lights.
1 = Front panel lights are always at DIM level.
2 = Front panel lights are always at BRIGHT level.
3 = Front panel lights AUTODIM after 4 seconds.

The DIM and BRIGHT intensities range from 0=Off, to 106=Maximum brightness. You cannot set the DIM level to be higher than or equal to the BRIGHT setting. Any attempt to do so will return an 'out of range' error.

Save Power On Default Settings

Saves the current HDMI5 settings as the power on default settings.

`S $`	Save current settings.
`S 246,$`	Restore all settings to their factory defaults.

There is no Response String for this command.

Note: Any value given, other than '246', will generate a range error.

Query Last IR Code Received

This command allows the controller to read the hash values returned by Zektor's IIR™ (Intelligent Infra-Red) decoding firmware. Zektor's IIR™ algorithm converts all IR codes it receives to a compressed, 72 bit value.

Each different key press of a remote control will generate a different but repeatable pattern.

This command returns a value for every IR code detected by the front panel IR sensor (or IR jack if enabled), regardless as to whether the IR code detected was used to control the HDMI5.

The uses for this command are two fold:

1) The value returned from this command are the same values used to teach the HDMI5 new IR codes over the serial port. (See the "**Set Learnable IR Command Codes**" command).

2) This command gives the controller full access to the HDMI5's IR sensor and Zektor's IIR™ algorithm. This is a very reliable way of adding IR control to any project. The IR codes generated by Zektor's IIR™ algorithm are immune to timing differences between universal remote control manufacturers and to the timing errors associated with condition of the remote control's battery.

Note 1: The Zektor's IIR™ algorithm works with any remote control code that is time modulated. This is pretty much every type of IR code except the Phillips RC-5, and RC-6 codes.

Note 2: Because very few controllers could handle a 72 bit decimal value, and in an effort to

HDMI5 Command Ref. *(Cont'd)*

Response String:

=P n

Where:
n = Current power status.

Output Mapping

Maps the HDMI5's output to a selected input.

O in	Set output to input 'in'.
O +	Sequence through inputs.
O ?	Query for current setting.
O	Query for current setting.

Response String:

=O in

Where:
in = Current input being mapped to the HDMI5's output.

Front Panel Light Intensities

Set the dim and bright levels of the front panel LEDs. Some examples:

LI mode,dim,bright	Set the MODE, DIM and BRIGHT levels.
LI mode,dim,bright,**$**	Set the MODE, DIM and BRIGHT levels, backup settings.
LI ,dim	Set only the DIM level.
LI ,,bright	Set only the BRIGHT level.
LI ?	Query for current settings.
LI	Query for current settings.

Response String:

=LI mode,dim,bright

Where:

mode	= Current MODE setting.
dim	= Current DIM level setting.
bright	= Current BRIGHT level settings.

Checksums and CRC-8's *(Cont'd)*

```
int main( void)
{
    char           TestString[] = "LI 2,3";
    unsigned char  crc8;
    int            index;
    char           token = ':';

    crc8 = CRC8_INIT;             // initialize checkcode

    // CRC8 all of TestString[]

    index = 0;

    while (TestString[index] != 0)
        crcByte( &crc8, TestString[index++]);

    // Add the CRC-8 token character ':' to CRC-8

    crcByte( &crc8, token);

    // Finish with CRC8 by doing a one's compliment

    crc8 = ~crc8;

    // Print the results

    printf( "%s%c%u", TestString, token, (unsigned char)crc8);
    return (0);
}
```

HDMI5 Command Reference

The HDMI5 K.I.S.S.™ Command Reference

This section defines the K.I.S.S.™ commands that are available to the users of the HDMI5.

Error Response Codes

The following are the Error Response codes that can be returned by the HDMI5.

!1<CR><LF>	Unrecognized command.
!2<CR><LF>	A parameter was out of range.
!3<CR><LF>	Syntax error, badly formed command.
!4<CR><LF>	Checksum or CRC-8 error.
!5<CR><LF>	Too many or too few parameters.
!6<CR><LF>	System busy cannot process command.
!7<CR><LF>	Buffer overflow.

And some more detailed descriptions of their meanings:

Error 1: The command given was not recognized as a HDMI5 command. Commands are case sensitive and in the HDMI5, all commands are upper case.

Error 2: One of the parameters given was too large, or too small, the command will be ignored.

Error 3: Something was wrong with the command's syntax. There was possibly extra data at the end of the line, or non-decimal data as part of a parameter. There cannot be whitespace before or after a checksum or CRC-8 checkcode, or this error will be returned.

Error 4: The ';' or ':' character was used to indicate a Checksum or CRC-8 Checkcode was appended to the command string, but the Checksum or CRC-8 Checkcode did not match the calculated one. The command will be ingnored.

Error 5: The number of parameters given does not match the number allowed by this command.

Error 6: To prevent conflicts between the front panel Setup Mode and the serial port settings, when the HDMI5 is in the Setup Mode, many parameters become read only and any attempt at writing them will return Error 6. The “Front Panel Button Emulation” command with button code ‘0’ can be used to exit the Setup Mode, at which point the command can be re-issued without an Error 6 response.

Error 7: An internal buffer has overflowed, for instance more than 16 button codes were sent as part of the “Front Panel Button Emulation” command.

The HDMI5 Command Set

Each command will be listed in all the different ways it can be issued. Usually each command has two different ways of being issued. The first is used to set its value, the second as a query command.

HDMI5 Command Ref. *(Cont'd)*

If the command has an associated response string, it will also be listed.

As described in the section on the K.I.S.S.™ protocol, whitespaces and commas are optional in many cases. The format used here includes a single space after the command and commas, with no spaces, between parameters. The format given here does not show the optional checksum or CRC-8 checkcodes that may be appended to all commands, nor does it show the required **<CR>** that terminates all commands.

The response strings are the strings returned from HDMI5, which use the same format as described above. The format does not show the optional checksum or CRC-8 checkcodes that may be appended to all response strings if enabled, nor does it show the **<CR><LF>** that terminates all Response Strings.

Version Query

Query for the current firmware version and PCB type of the HDMI5.

V ?	Request version string.
V	Request version string.

Response String:

=V HDMI5 firmware_ver **(**pcb_rev**)**

Where:

firmware_ver = Version number of the HDMI5's firmware.
pcb_rev = PCB Revision.

Power Control

Turn on / off, or toggle the power state of the HDMI5.

P 0	Turn off power.
P 1	Turn on power.
P +	Toggle power.
P ?	Query for current setting.
P	Query for current setting.